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The minimally invasive approach for lateral malleolus fractures plating demonstrating less pain, shorter operative time and earlier discharge compared to open approach: a prospective randomized controlled trial

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Abstract

Background Open reduction and internal fixation (ORIF) has been a long-established and accepted technique for the treatment of lateral malleolar fractures. However, minimally invasive percutaneous plate osteosynthesis (MIPPO) may be preferred in cases with compromised soft tissue conditions or in the presence of comorbidities. MIPPO is increasingly being used in the treatment of long bone fractures. The aim of this study was to compare the clinical, functional and radiological outcomes of the MIPPO technique for lateral malleolus fractures with those of ORIF.

Methods This prospective randomized controlled study analysed patients who underwent surgery for lateral malleolus fractures treated with ORIF or MIPPO between the years 2022 and 2024. The study included patients with lateral malleolus fractures of Danis–Weber types B and C requiring surgical intervention. Postoperative pain, the American Orthopaedic Foot and Ankle Society (AOFAS) score, hospital stay, surgical time, fluoroscopy time, and radiological measurements were compared.

Results The study included 68 patients (ORIF $n=34$, MIPPO $n=34$). The minimum follow-up for all the patients was 12 months and maximum was 24 months with a mean of 18,20 months postoperatively. The postoperative pain scores at 8 h ($p=0.001$), 24 h ($p<0.001$) and 2 weeks ($p=0.003$) were lower in the MIPPO group. Pain scores were similar between the preoperative measurement and those observed at 4 weeks, 6 weeks, 3 months, 6 months and 1 year postoperatively. AOFAS scores were similar between both groups at 3 months, 6 months and 1 year postoperatively. Surgical time and the postoperative hospitalisation period were shorter in the MIPPO group ($p<0.001$, $p=0.005$). A higher level of fluoroscopy exposure was observed in the MIPPO group ($p=0.001$). Similar results were obtained in radiological measurements between groups.

Conclusion The MIPPO technique leads to lower pain scores in the short term, shorter surgery times, and earlier discharge. In the long term, it provides similar clinical, functional, and radiological results to those obtained with ORIF.

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Keywords Lateral malleolus fracture, Minimally invasive surgery, Open reduction, Postoperative pain, Randomized clinical trial

Introduction

Ankle fractures are a common injury seen in orthopaedic clinics, but the incidence of lateral malleolus fractures has been increasing in recent years, accounting for approximately 9% of all bone fractures [1, 2]. Minimally invasive surgical approaches are increasingly utilized due to their potential to reduce soft-tissue trauma, postoperative pain, and length of hospital stay when compared with conventional open techniques [3–7]. Some publications use arthroscopic support for fracture reduction [8]. Lateral malleolar fractures frequently necessitate surgical intervention to alleviate pain and re-establish functional stability of the ankle joint.

The surgical approaches for treating these fractures include open reduction-internal fixation (ORIF) and minimally invasive techniques such as minimally invasive percutaneous plate osteosynthesis (MIPPO), the fibula nail, rush pin or intramedullary screw fixation [9–13]. The aim of this study was to compare the short-term clinical, functional, and radiological outcomes of MIPPO and ORIF for lateral malleolus fractures.

Methods

This prospective randomised controlled study was performed in a single medical centre at Giresun training and research hospital between October 2022 and January 2024. Approval for this study was obtained from the Ethics Committee of Ordu University Faculty of Medicine (decision number 2022/229). Clinical Trials application was made, and authorisation was obtained with decision number NCT06753656. The study was conducted in accordance with the Declaration of Helsinki. Patients who underwent operation for lateral malleolus fracture were included in the study. The patients were informed about the procedure to be performed prior to surgery, and informed consent to participate in the study was obtained.

The inclusion criteria were volunteering to participate, closed distal fibula epiphysis, fractures classified as Weber type B and C according to the Dennis–Weber classification [14, 15], and patients with regular follow-up at outpatient clinics. The exclusion criteria were open fractures, medial malleolus, pilon or talus fractures, previous fracture/surgery on the same ankle fracture or another one, arthrosis, pathological fractures, multi-trauma and polytrauma patients, psychiatric or neurological disease, illiterate patients, and congenital or acquired deformity of the lower extremities. Anteroposterior (AP), lateral, and mortise radiographs of the ankle were obtained at the time of the patient's admission (Figs. 1A–C).

Radiological measurements of the medial clear space, tibiofibular overlapping, tibiofibular clear space, talocrural angle and talar tilt were planned for the fractured and intact sides. Radiological measurements were performed twice at different times after the fracture healed and compared by taking the average. The surgeons who performed the operations were not involved in applying the scoring assessments. Surgical intervention for lateral malleolus fractures is indicated when ankle mortise stability is compromised (including deltoid ligament insufficiency or syndesmotic disruption), when the fracture exhibits displacement or fibular shortening, or in the presence of bimalleolar or trimalleolar injury patterns.

The study was designed as a randomized controlled trial. Prior to the study, a power analysis was conducted, which indicated that a minimum of 34 patients would be needed in each group to achieve 90% power. An additional 4 patients per group was included to account for potential patient loss during the study. Patients were assigned numbers according to their order of admission. Prior to the study, a randomization program was used to divide the patients into two groups. The surgical fixation method was determined as either MIPPO or ORIF based on the group to which the patient's number belonged. 76 patients underwent operations, and the study was completed with 68 patients who met the inclusion criteria.

Surgical technique

The principles of fracture surgery were followed for both groups. These include restoration of fibula length, stable internal fixation, preservation of soft tissue and blood supply, early mobilization, and rehabilitation. The operations were performed for all patients after swelling of the soft tissue had resolved to decrease the chance of soft-tissue complications. To assess soft-tissue swelling, the skin pinch test was performed. In the open surgery group, a skin incision was made slightly posterior to the lateral aspect of the fibula, and the bone was advanced without stretching the soft tissue by sharp dissection. If a plate with six or more holes is planned for fixation, the superficial peroneal nerve and its terminal branches should be surgically explored starting approximately 5–7 cm proximal to the distal tip of the fibula to prevent iatrogenic injury [16, 17]. After the fracture was open-reduced, it was held with a reduction clamp. Fixation was achieved with a distal fibula anatomic plate. When the fracture morphology was deemed suitable, the use of a lag screw was left to the discretion of the operating surgeon. If a lag screw was utilized, it was placed first to achieve fracture compression. Then, the plate was fixed to the bone with

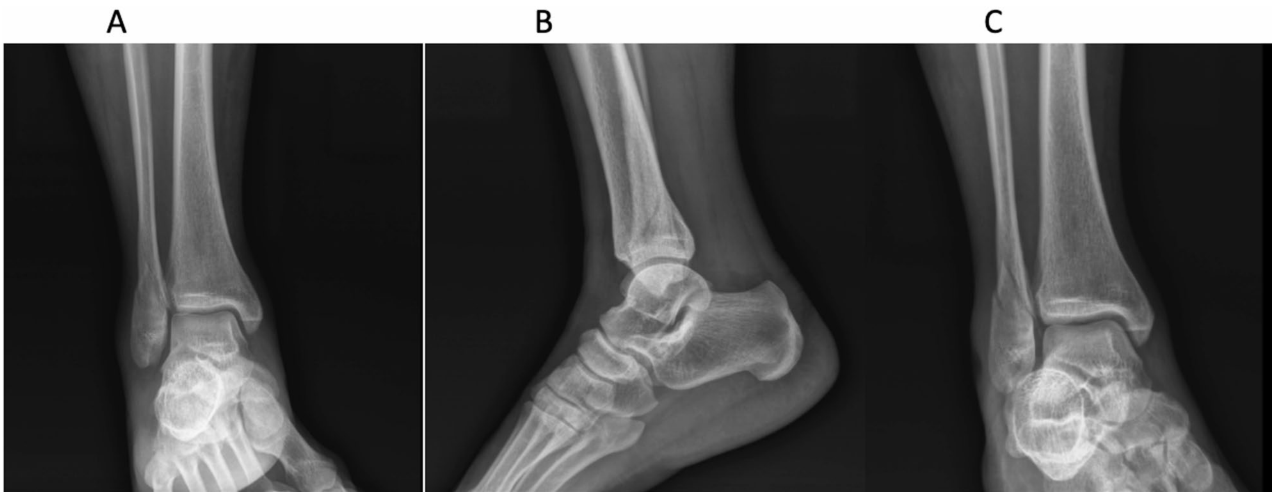

Fig. 1 Pre-operative X-Rays, **A**: Anterior-Posterior X-ray, **B**: Lateral X-ray, **C**: Mortis X-ray

a cortical screw placed proximal to the fracture. Subsequently, the distal segment of the plate was secured using locking screws, and finally, the proximal segment of the plate was fixed with locking screws. The same type and brand of plate was used for all patients. We used 3.5 mm thickness, Distal fibula anatomical locking plates and screws (Ases Medical, Gaziantep, Turkey).

Fracture reduction and plate positioning were monitored using fluoroscopy in the AP, mortis and lateral planes. The plate was fixed to the bone with screws. Following fixation of the lateral malleolus fracture, an external rotation stress test was performed to evaluate the integrity of the syndesmosis. When a syndesmotic injury was identified, transsyndesmotic stabilization was performed using either a screw or a suture-button device, with the choice of fixation determined at random according to the surgeon's preference [18].

In the MIPPO technique, the patient was initially prepared in the same way as for the ORIF group, and then the fibula, fracture line, and incisions were drawn with a sterile skin pen (Fig. 2A). A skin incision with a length of approximately 2 cm was made distally from the apex of the lateral malleolus. Sharp dissection was performed through the bone tissue. With a blunt dissector, soft tissue dissection was performed through the periosteum along the bone where the plate would be placed. Without evacuating the fracture hematoma, closed reduction was achieved using a reduction clamp or a Weber clamp applied percutaneously over the skin (Fig. 2B).

In this technique, the adequacy of fracture reduction was assessed under fluoroscopic guidance by confirming cortical continuity in all four cortices on anteroposterior and lateral radiographic views. The plate was advanced along the open path and fixed with K-wires from the proximal and distal parts. Fracture reduction and plate position were re-evaluated in the AP and lateral planes under fluoroscopic guidance. A second plate of the same length was applied over the K-wires and used as an external guide to prevent exposure to fluoroscopy for screw-hole determination in closed surgery [6] (Fig. 2C). The planned screw holes were drilled through mini-incisions, and the screw fixation sequence and syndesmosis joint fixation requirement were determined according to the method applied in the open surgery group (Fig. 2D). If a plate with six or more holes is planned for fixation, the superficial peroneal nerve and its terminal branches should be surgically explored starting approximately 5–7 cm proximal to the distal tip of the fibula to prevent iatrogenic injury [16, 17].

Post-operative care and follow-up

All patients in the ORIF and MIPPO groups underwent the same aftercare and follow-up protocol. On the first day post-operatively, AP, lateral, and mortise radiographs of the ankle were obtained for patient follow-up (Figs. 3A–C).

All ankles were immobilised in a short leg back slab for 2 weeks to aid soft-tissue healing. All patients were mobilized with crutches without putting any load on the operated foot. On day 15, the sutures and splint were removed and active and passive range of motion (ROM) movement of the ankle was started. At 6 weeks, partial load was applied. If a syndesmosis screw was present, it was removed in week 6. Full loading was started at 10 weeks postoperatively. The syndesmotic screw was removed under sterile conditions in the clinic using local anesthesia. Removal of the syndesmosis screw did not change the postoperative follow-up and rehabilitation protocol [19].

Patient follow-up was performed clinically and radiologically. A numerical pain-rating scale (NPRS) was used to determine pain scores, which were obtained preoperatively and postoperatively at 8 h, 24 h, 2 weeks, 4

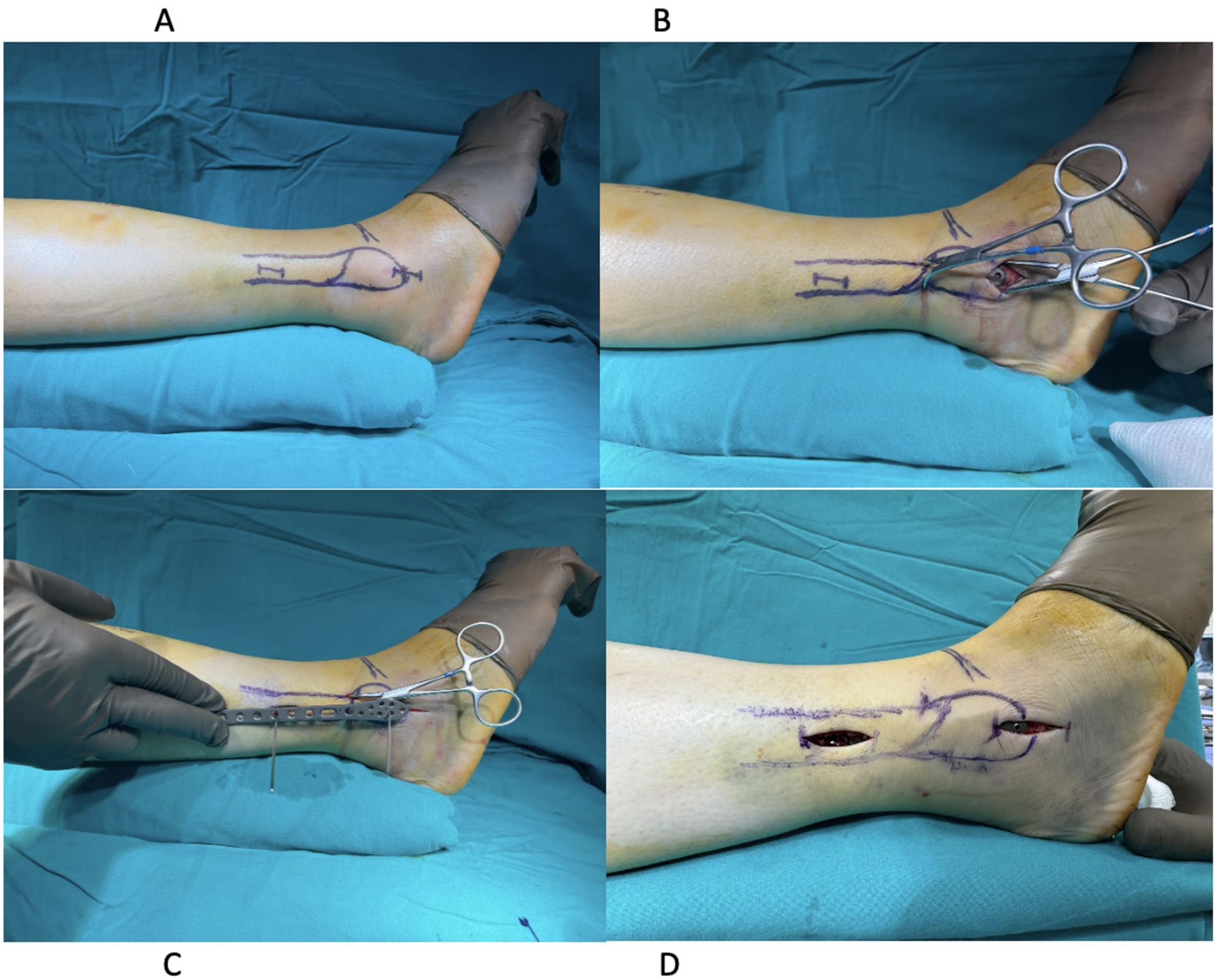

Fig. 2 MIPPO surgical technique, **A**: skin incisions, **B**: MIPPO surgical technique percutaneous reduction of fracture, **C**: MIPPO surgical technique creating an external guide with a long hole plate, **D**: MIPPO surgical technique ankle appearance after surgery

Fig. 3 Post-operative X-Rays, **A**: Anterior-Posterior X-ray, **B**: Lateral X-ray, **C**: Mortis X-ray

weeks, 6 weeks, 3 months, 6 months, and 1 year. American Orthopaedic Foot and Ankle Society (AOFAS) scores were obtained to assess ankle functionality at 3 months, 6 months, and 1 year post-operatively.

Standard anteroposterior, mortise, and lateral radiographs were obtained with the lower extremity positioned in neutral alignment. All measurements were performed on non–weight-bearing radiographs. The medial clear space, tibiofibular overlap, tibiofibular clear space, talocrural angle, and talar tilt angle were measured in all patients. These measurements were comparatively evaluated between the fractured and contralateral uninjured sides, as well as between the fractured sides of both study groups. Radiographic measurements were performed after complete fracture union had been achieved. To ensure blinded assessment, radiographs were anonymized by assigning different identification numbers and were independently evaluated by two orthopedic surgeons. Initially, the uninjured sides of 10 randomly selected patients from the study group were measured jointly by both observers for calibration purposes. Subsequently, all radiographs were measured twice by each observer at different time points. The mean values of the second measurements were used for statistical analysis (Fig. 4A and B).

Statistical analysis

Descriptive statistics are presented using frequencies, percentages, means, standard deviations, medians, minimums, maximums, and 25th – 75th percentile (Q1–Q3) values. The assumption of normality was evaluated using the Shapiro–Wilk test, along with histogram analysis, Q–Q plots, skewness, and kurtosis values. For the analysis of the differences between the numerical data of the two groups, an independent-samples *t*-test was used when the data adhered to a normal distribution, while the Mann–Whitney *U* test was used when normality conditions were not met.

Fig. 4 Follow up X-Rays, **A**: Anterior-Posterior X-ray, **B**: Lateral X-ray

In the comparison of two dependent measurements, the Wilcoxon signed rank test was used when the distribution of the groups did not follow a normal distribution. To assess whether there were differences in time-dependent measurements across groups, the Friedman test was conducted when the data did not exhibit a normal distribution. In cases of significant results, pairwise comparisons were performed using the Bonferroni–Dunn procedure. For relationships between categorical variables, Pearson's chi-squared test was applied when the proportion of cells with an expected value less than 5 was below 20%, and Fisher's exact test was used when it exceeded 20%. Results were considered statistically significant in cases of *p*-values less than 0.05. The analyses were conducted using the software package SPSS 23.0.

Results

The study was completed with 68 patients, and 34 patients were included in each group. 36 (52.9%) of the patients were male, 32 (47.1%) were female and the mean age was 48.20±16.09 years. The fracture was on the left side in 33 (48.5%) patients and the right side in 35 (51.5%) patients. 64 (94.1%) patients had fractures with Weber type B, and 4 (5.9%) patients had Weber type C. The aetiologies of the fractures were falls for 42 (61.7%) patients, twisting injury for 19 (27.9%) patients, motor-vehicle accidents for 4 (5.9%) patients, and blunt trauma for 3 (4.4%) patients.

22 (32.3%) patients had associated posterior malleolus fracture but did not undergo surgical fixation. All posterior malleolus fractures were Haraguchi type 3, and none of them underwent surgical fixation. Syndesmosis fixation was performed with screws for 39 (57.3%) patients and with suture buttons for 4 (5.9%) patients. Regarding educational status, 32 (46.9%) patients had a primary-level education, 28 (41.1%) patients had a secondary-level education, and 8 (11.7%) patients had a high-school education. 28 (41.1%) patients were smokers, and 12 (17.6%) patients had type 1 or 2 diabetes mellitus. The demographic data are shown in Table 1.

The minimum follow-up for all the patients was 12 months and maximum was 24 months with a mean of 18.20 months postoperatively. There was no statistically significant difference between the two groups in terms of follow-up period ($p > 0,05$). The NPRS scores were significantly lower in the MIPPO group at 8 h, 24 h, and 2 weeks postoperatively. The mean NPRS score at 8 h was 6.35 ± 1.98 in the MIPPO group and 7.94 ± 1.97 h in the ORIF group ($p = 0.001$). The NPRS score at 24 h was 3.38 ± 1.60 in the MIPPO group and 5.12 ± 1.92 in the ORIF group ($p < 0.001$). At 2 weeks, the mean NPRS score was 0.88 ± 1.04 in the MIPPO group and 1.85 ± 1.42 in the ORIF group ($p = 0.003$). The results were similar at other follow-ups ($p > 0.05$) (Table 2).

Table 1 Demographic data in both groups

	MIPPO (*n*:34)	ORIF (*n*:34)	*P* values
Gender	20 (%29.4)	16 (%23,5)	0,331
Male	14 (%20.6)	18 (%26,5)	
Female			
Age (y)	46.35 ± 18.70	50.06 ± 13.02	0,547
Body mass index (kg/m^2)	27,21 ∓ 2,46	28,35∓ 3,74	0,143
Side injury	15(%22)	18(%26,4)	0,467
Left	19(%27,9)	16(%23,5)	
Right			
Smoker	13 (%19.1)	15(%22)	0,622
Yes	21 (%30.9)	19(%27,9)	
No			
Diabetes	4 (%5.9)	8 (%11,7)	0,203
Yes	30 (%44.1)	26 (38,2)	
No			
Mechanism of injury	10 (%14,7)	9 (%13.2)	0,687
Twisting injury	22 (%32,3)	20 (%29.4)	
Fall	1 (%1.5)	3 (%4.4)	
MVA	1 (%1.5)	2 (%2.9)	
Blunt trauma			
Weber classification	33 (%4.5)	31 (%45.6)	0,303
B	1 (%1.5)	3 (%4.4)	
C			
Tscherne soft tissue	27 (%39,7)	30 (%44.1)	0,323
0	7 (%10,2)	4 (%5.9)	
1			
Accompanied by posterior	10 (%14.7)	12 (%17.6)	0,604
malleolus fracture	24 (%35.3)	22 (%32.4)	
Yes			
No			
Syndesmosis fixation	14 (%20.6)	11 (%16.2)	0,708
No	19 (%27.9)	20 (%29.4)	
Screw	1 (%1.5)	3 (%4.4)	
Suture button			
Education	18 (%26,4)	14 (%20,5)	0,565
Primary	13 (%19,1)	15 (%22)	
Secondary	3 (%4,4)	5 (%7,3)	
Higher			
Anaesthesia	3 (%4.4)	6 (%8,82)	0,283
General	31 (%45.6)	28 (%41,1)	
Spinal			
ASA score	7 (%10,2)	11 (%16,1)	0,272
1	27 (%39,7)	23 (%33,8)	
2			

MVA: motor vehicle accident

Table 2 Post operative results of both groups

	MIPPO (*n*:34)	ORIF (*n*:34)	*P* values
Follow up (month)	18,15 ± 3,59	18,26 ± 3,70	*p* = 0,882
NPRS scores (0–10)	3,47 ± 2,11	3,68 ± 2,11	*p* = 0,435
Pre-op	6,35 ± 1,98	7,94 ± 1,97	*p* = 0,001*
Post op 8th hour	3,38 ± 1,60	5,12 ± 1,92	*p* < 0,001*
Post op 24th hour	0,88 ± 1,04	1,85 ± 1,42	*p* = 0,003*
Post op 2nd week	0,53 ± 1,24	0,74 ± 0,83	*p* = 0,055
Post op 4th week	0,50 ± 1,19	0,50 ± 0,83	*p* = 0,317
Post op 3rd month	0,18 ± 0,63	0,38 ± 0,99	*p* = 0,192
Post op 6th month	0,12 ± 0,54	0,15 ± 0,56	*p* = 0,655
Post op 1 st year			
AOFAS scores (0–100)	90,12 ± 7,91	88,79 ± 8,29	*p* = 0,482
Post op 3rd month	98,32 ± 2,90	95,79 ± 6,39	*p* = 0,255
Post op 6th month	99,35 ± 2,40	98,85 ± 3,60	*p* = 0,650
Post op 1 st year			
Surgery time (minute)	48,59 ± 5,87	71,09 ± 7,11	*p* < 0,001*
Post-operative hospital stay (day)	1,26 ± 0,51	1,62 ± 0,55	*p* = 0,005*
Fluoroscopic time (second)	21,41 ± 10,86	13,71 ± 5,26	*p* = 0,001*
Numbers of Fluoroscopic	35,44 ± 19,05	23,53 ± 9,06	*p* = 0,003*

* Statistically significant difference (*p* < 0,05)

Table 3 Post-operative complications and types

Complications	MIPPO(*n*:34)	ORIF(*n*:34)	*P* value
Yes	2 (%2,9)	5 (%7,3)	0,231
Infections	2 (%2,9)	2 (%2,9)	
Wound dehiscence	0 (%0,0)	1 (%1,5)	
Screw breakage	0 (%0,0)	1 (%1,5)	
Hardware irritation	0 (%0,0)	1 (%1,5)	
No	32 (%47,1)	29 (%42,6)	
Total	34 (%50)	34 (%50)	

The AOFAS scores were similar between groups at 3 months, 6 months, and 1 year ($p > 0.05$) (Table 2). The MIPPO groups' surgical time was significantly lower at 48.59±5.87 min in the MIPPO group versus 71.09±7.11 min in the ORIF group ($p < 0.001$). The post-operative discharge times were significantly shorter in the MIPPO group. The postoperative hospitalization period was 1.26 ± 0.51 days for the MIPPO group and 1.62 ± 0.55 days for the ORIF group ($p = 0.005$) (Table 2).

The number and duration of fluoroscopy exposures were significantly lower in the ORIF group. The mean duration of fluoroscopy was 13.71 ± 5.26 s in the ORIF group and 21.41 ± 10.86 s in the MIPPO group ($p = 0.001$). The mean number of fluoroscopies was 23.53 ± 9.06 in the ORIF group and 35.44 ± 19.05 in the MIPPO group ($p = 0.003$) (Table 2).

Although complications were more common in the ORIF group, there was no statistically significant difference between the two groups in this regard ($p > 0.05$) (Table 3).

There was no difference between the radiological measurements of the ankles on the fractured side and intact side for both groups ($p > 0.05$). There was also no difference in radiological measurements between the two groups on the fractured sides ($p > 0.05$) (Table 4).

Discussion

ORIF is widely regarded as the gold standard for managing displaced and unstable lateral malleolus fractures [20, 21]. However, there has been increasing awareness of the importance of preserving fracture hematoma and adjacent soft tissue to foster fracture healing and minimize complications, which has led surgeons to investigate minimally invasive surgical techniques. Although

Table 4 Comparison of the radiological measurements of the fractured side and the intact side in both groups and fracture sides in both groups

Radiological measurement	Surgical fixation		*P* value
	MIPPO(*n* = 34)	ORIF(*n* = 34)	
Medial clear space (mm)			
Postoperative	3,28 ± 0,76	3,27 ± 0,71	0,991
Contralateral	3,37 ± 0,63	3,11 ± 0,67	
P value	0,266	0,080	
Tibiofibular overlap (mm)			
Postoperative	8,18 ± 2,41	7,72 ± 2,50	0,447
Contralateral	8,22 ± 2,45	7,61 ± 2,39	
P value	0,897	0,662	
Tibiofibular clear space (mm)			
Postoperative	4,52 ± 1,24	4,93 ± 2,17	0,641
Contralateral	4,38 ± 0,96	5,12 ± 1,45	
P value	0,538	0,350	
Talocrural angle (°)			
Postoperative	80,00 ± 5,17	78,93 ± 4,15	0,225
Contralateral	80,61 ± 5,46	78,70 ± 4,18	
P value	0,590	0,171	
Talar tilt (°)			
Postoperative	1,05 ± 0,65	1,12 ± 0,87	0,868
Contralateral	1,15 ± 0,66	1,14 ± 0,68	
P value	0,438	0,981	

these approaches are routinely employed for long bones such as the femur and tibia, their use for lateral malleolus fractures has gained considerable traction in recent years [2, 9, 11, 22, 23]. In this prospective randomized controlled study, we compared the results of the MIPPO technique to those of ORIF for lateral malleolus fractures with a particular focus on postoperative pain and length of hospital stay. The findings indicated that MIPPO offers distinct advantages in terms of early postoperative pain management and expedited discharge, while long-term functional outcomes were comparable between the two techniques.

Initially, the MIPPO group demonstrated lower pain levels at 8 and 24 h and at the 2-week follow-up compared with the ORIF group. This result substantiates that minimally invasive approaches mitigate soft-tissue trauma, thereby reducing postoperative pain during the early recovery period. However, we observed no significant differences between the two groups in pain scores at 4 weeks, 6 weeks, 3 months, 6 months, and 1 year. While the MIPPO technique resulted in less pain in the early period, similar results were observed in both techniques in the long term. Chiang et al. found significantly lower pain scores in patients treated with MIPPO compared with those treated with ORIF [3]. Furthermore, Marazzi et al. reported a higher level of residual pain in the ORIF group compared with the MIPPO group [4].

Another key finding of our study is the shorter hospital stay in the MIPPO group. However, in the retrospective study by Marazzi et al., which included 35 patients each in the MIPPO and ORIF groups, no significant difference was observed in the total length of hospital stay between the two techniques [4, 24].

In the functional assessment performed using AOFAS, no significant difference was observed between the two groups at 3 months (p > 0.05), 6 months (p > 0.05), and 1 year (p > 0.05). Similarly, Chiang et al. evaluated AOFAS scores at 3, 6 months, and the final follow-up and reported similar findings between the two groups. Iacobellis et al. assessed functional outcomes using the Olerud–Molander score, and the MIPPO group achieved a mean score of 95.6 (range: 82–100) compared to 87.4 (range: 80–100) in the ORIF group [3, 5].

The MIPPO group had a significantly higher mean fluoroscopy time and number of exposures than the ORIF group. Similarly, Chiang et al. found that the mean fluoroscopy time and radiation dose were significantly higher in the MIPPO group, and Iacobellis et al. observed increased fluoroscopy times in the MIPPO group compared to the ORIF group. However, the high fluoroscopy exposure involved in the MIPPO technique can be reduced by using the technique described by Aytekin et al. [3–6, 25].

The surgical time was significantly lower in the MIPPO group than in the ORIF group. Iacobellis et al. and Marazzi et al. obtained similar results in regard to mean surgical time. However, Chiang et al. reported longer operative times in the MIPPO group than in the ORIF group. We attribute the differences in results in the literature to the steep learning curve of the MIPPO technique. These times may be shortened as the surgeon's experience with the technique increases [3–5].

In the standard surgical approach using ORIF for lateral malleolus fractures, documented complications in the literature include infection, wound problems, plate irritation, and nonunion with rates of up to 30%. Several studies suggest that the MIPPO technique may reduce the incidence of these complications [22, 26, 27]. Zakaria et al. demonstrated in their prospective study that successful outcomes can be achieved using the MIPPO technique in lateral malleolus fractures where soft tissue condition is severe and the risk of complications may be high [24]. To minimize these risks, it is important to wait until soft-tissue conditions are optimal, particularly in this region of thin soft tissue coverage, to maintain gentle and careful retraction during surgery, to perform dissection at the deepest level possible, and to close the wound without tension [12, 26, 28–31]. In the present study, although complications were more common in the ORIF group, the difference was not statistically significant.

In the radiological assessments, we first compared the fractured ankle to the intact ankle within each patient and then compared the fractured ankles between the MIPPO and ORIF groups, but no statistically significant differences were observed in either comparison (p > 0.05, p > 0.05). Chiang et al. conducted similar analyses and also found no statistically significant differences [3]. Marazzi et al. employed the same radiological measurements to compare both techniques and observed more tibiofibular overlap in the MIPPO group, but no notable differences were detected for the other parameters [4].

One of the limitations of this study was the short follow-up period. Additionally, bimalleolar/trimalleolar ankle fractures requiring surgical fixation have been excluded. However, the MIPPO technique should primarily be applied and compared in bimalleolar and trimalleolar fractures resulting from high-energy trauma, where soft tissue may be problematic. Further studies with larger patient cohorts and longer follow-up durations would provide a more comprehensive evaluation of the long-term efficacy and safety of the MIPPO technique.

Conclusion

Our analysis and previous studies indicate that the MIPPO method is a preferable approach for managing lateral malleolus fractures over the ORIF method. For example, MIPPO is associated with reduced pain and shorter hospital stays. Nevertheless, it also has disadvantages such as high radiation exposure.

Ethical approval

Ethics approval for this study was provided by the Clinical Research Ethics Board at the University of Ordu, 2022/229. Clinical Trials was applied and the approval number is NCT06753656. Patients gave informed consent prior to participating in this study.

Abbreviations

ORIF	Open reduction and internal fixation
MIPPO	Minimally invasive percutaneous plate osteosynthesis
AOFAS	American orthopaedic foot and ankle society
AP	Anteroposterior
ROM	Range of motion
NPRS	Numerical pain rating scale

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13018-025-06624-z.

Supplementary Material 1

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None reported.

Author contributions

EK and KA: Concept or design, EK, HK and ET: Acquisition of data, EK, TD and KA: Analysis or interpretation of data, EK, TD and HK: Drafting of the article, TD, ET and KA: Critical revision for important intellectual content. All authors read and approved the final version of the manuscript.

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Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

Local ethics committee approval has been obtained for publication. The Clinical Trials application has been completed and approved. Informed consent was obtained from all individual participants included in the study.

Consent for publication

Patients were informed about the figures used in the publication, and their consent for sharing and informed consent were obtained.

Competing interests

The authors declare no competing interests.

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